ABSTRACTS
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This year for the first time we are publishing **ABSTRACTS** of papers, as well as of symposium presentations, of the Forty-seventh Annual Meeting of the Eastern Branch, Entomological Society of America, held Oct. 1975, in Philadelphia, Pa. The New York Entomological Society and the Eastern Branch, ESA, hope that publication of **ABSTRACTS** will become a regular procedure and that future December issues will be devoted, in part, to subjects presented at the Annual Meeting of the Eastern Branch.

ACKNOWLEDGMENT

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Seasonal Variations in Activity of *Apanteles melanoscelus* Ratzeburg (Hymenoptera: Braconidae) Adults as Related to Seasonal Variations in Age Structure of its Host, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae)

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Apanteles melanoscelus Ratzeburg does not develop successfully in large larvae of the gypsy moth, *Porthetria dispar* (L.). This study was conducted to determine if the effectiveness of the second field generation of the parasitoid is reduced because of this. Field attack frequency of female *A. melanoscelus* was monitored weekly by confining laboratory reared 1st and 2nd stadia gypsy moth larvae to branches of trees and then rearing them in the laboratory to see if they were parasitized. Also, weekly collections of 100 gypsy moths were taken in the field, their stadia recorded, and reared to determine percent parasitism. First and 2nd stadia gypsy moth larvae were abundant in the field from May 20 up to June 13. Third instars, which *A. melanoscelus* does attack but with difficulty, occurred through June 19. Attack frequency of *A. melanoscelus* on confined, laboratory-reared small larvae was low until June 10–13, when it increased dramatically and then declined in subsequent weeks. This peak was probably due to second generation emergence of the parasitoid. Thus, *A. melanoscelus* adults are most abundant when most gypsy moth larvae are too large to be suitable hosts (by June 13, 79.3% of the field-collected caterpillars were 4th instars and larger). This could be expected to influence considerably the parasitoids, ability to control the pest.

Dimilin Toxicity to *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae) and Effects on Field Populations

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In the laboratory *Apanteles melanoscelus* (Ratzeburg) larvae were treated with Dimilin®, 1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)-urea, by feeding treated artificial diet to the gypsy moth host. The parasitoid EC_{50} was 0.0059 ppm in comparison with 0.0075 ppm for the unparasitized gypsy moth. At low treatment rates the parasitoids died during the pupal-adult molt within the cocoon. At high treatment rates, however, the parasitoids died as larvae within the gypsy moth larvae. Treatments while the parasitoids were 2nd-3rd stadial larvae had less effect than treatments earlier in the parasitoids' development. Dimilin did not apparently affect parasitoids treated as adults. The toxicity of Dimilin was a direct effect of the chemical and not due to host morbidity. These results indicate that Dimilin may be used in an integrated approach to gypsy moth control. To test this, orchard sprays of Dimilin were made while gypsy moth larvae were at: 1) the 1st-2nd larval stadium, 2) 2nd-3rd stadium and 3) 3rd-4th stadium. No parasitoids emerged from larvae collected from treated trees 1 week after the first spraying. However, there was little effect on numbers of emerged parasitoid cocoons when larvae were collected from trees sprayed thereafter. Dimilin had no marked effect on adult emergence from cocoons. Thus if timed properly Dimilin should have little effect on populations of *A. melanoscelus* and yet still control the gypsy moth.

Effects of the Insect Growth Regulator Altozar on the Parasitoid, *Microctonus aethiops*, and Its Host, *Hypera postica*

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The insect growth regulator Altozar® terminated sexual diapause of adult alfalfa weevils when topically applied. In addition, it terminated the diapause of *M. aethiops* when applied to parasitized adult weevils. Parasitoid survival and morphological condition were influenced by various Altozar® concentrations. An interaction was also found between age of non-diapausing parasitoids at the time of treatment and concentrations of Altozar® employed.

Mass Rearing of *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae) on *Liriomyza trifoliearum* Spencer (Diptera: Agromyzidae)

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The object of the study was to find a method of rearing large numbers of the parasite, *Diglyphus isaea* (Walker), for release against its target host, alfalfa blotch leafminer, *Agromyza frontella* (Rondani). Mass rearing of *D. isaea* on alfalfa blotch leafminer proved difficult because of the time and inconvenience of handling the puparia of the fly which pupates in the soil, the small numbers of larvae (50–100) available for parasite oviposition per 6″ pot of alfalfa, several troublesome pest contaminants of alfalfa, and the lengthy time required to grow alfalfa from seed or allow its regrowth after cutting. *Liriomyza trifoliearum* Spencer was found to be a host acceptable to the parasite. It was reared on Burpee™ Bountiful bush beans, a host plant on which no contaminant species have as yet been found in culture. The first pair of true leaves of the bush bean are suitable for oviposition by the fly 6–7 days after planting, at 78°F. A 5″ × 8″ pot of 20 plants will produce 1000–1500 larvae. At 78°F the host larvae eclose and reach the final (3rd) instar in 6 days, at which time they are placed in cages with parasites. It is important to provide the parasite with 3rd instar host material only. They sting and kill earlier instars, but no oviposition has been observed. Maturation of the parasite requires 13–23 days at 73°F. Thus in about a month it is possible to go from host plant seed to mature parasite. The use of *L. trifoliearum* as an alternate host on bush beans (as opposed to using alfalfa blotch leafminer on alfalfa) saves time and space and results in far larger numbers of *D. isaea*.

Control of the Apple Leaf Curling Midge, *Dasyneura mali* (Kieff) (Diptera: Cecidomyiidae) in New Hampshire

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A block of apples in Durham, New Hampshire, heavily infested with the apple leaf curling midge, was treated with several regularly recommended and experimental materials. Treatments were made on the following dates: 5/1/75 (Green Tip); 5/8/75 (Tight Cluster); 5/15/75 (Pink); 5/26/75 (Petal Fall); 6/5/75 (1st Cover); 6/11/75 (2nd Cover), before efficacy data was recorded (6/23/75). Treatments were randomized, replicated two or three times, and applied in 350 gal. H_2O/A at 300 psi. Materials applied were: Zolone 3EC 1 pt/100; Furadan 4F 0.25 lb.ai/100; Parathion 2S 0.5 lb.ai/100; N2596 4EC 1.0 lb.ai/100; Imidan 1S 0.5 lb.ai/100; Lannate 0.5 lb.ai/100; Lannate 0.25 lb.ai/100 plus Guthion 50WP 0.25 lb.ai/100; Guthion 50WP 0.5 lb.ai/100; Mobil 9087 2EC 0.75 lb.ai/100; TH6042EC 0.5 oz.ai/100; TH6042EC 0.132 oz.ai/100; Bayhox 1901 40WP 4oz.ai/100; FMC 3329 3EC 0.1 lb.ai/100; Bayntn 9306 6EC 4oz.ai/100. Data was obtained by counting the number of curled leaves per tree. These counts were totaled, replicate averages made and percent control corrected with Abbotts formula. The commonly used insecticides, Guthion, Zolone and Imidan gave 100% control which probably accounts for the minor occurrence of this pest in New England commercial orchards. Parathion 2S and Lannate gave poor control. Treatments with Mobil 9087, TH6082, Bayhox 1901, FMC 3329, Bayntn 9306 resulted in 100% control, N2596, 99% control, and TH6082 at 0.132 gave 92% control.

Is a Black Fly Survey Worthwhile?

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The town of Jackman, Maine, was surveyed to determine the sources of black flies that cause severe annoyance from May to July. Prior attempts at larval control requiring treatment of all swift-water areas had met resistance from environmentalists since they felt the ecology of the area might be disturbed. It was suggested that a survey might reveal localized areas of high productivity in certain streams. Therefore, all streams within a 259 m^2 area surrounding the town were monitored during 1970 to determine productivity and species present. Numerous biting collections supplemented larval and pupal collections. Results of the survey showed that *Simulium venustum* Say accounted for more than 98% of the annoyance in the area and an estimated 85% of this species was found to develop in two separate stretches of Wood Stream. Heald Stream and certain areas of several other streams were productive although they are considered rather minor sources of *S. venustum.* Some streams did not produce this species and others produced very few. Results of the study suggest that a black fly survey can be as useful as a mosquito survey in locating breeding sites for source reduction. The cost of a survey should be considered minor as compared with the savings realized if a larval control program should be implemented. Since the amount of insecticide required for control would be markedly reduced, the risks to non-target organisms also would be minimized.

A Comparison of Malaise Trapping and Aerial Netting for Research on Houseflies and Deerflies (Diptera: Tabanidae)

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Fifty species of Tabanidae were collected near Deer Lake, Booton, N.J. during the summer of 1974 while comparing the effectiveness of malaise trapping and aerial netting for sampling tabanids. Five sites in the study area were sampled by malaise traps and by sweeping (netting) about the head with an insect net. Comparisons were made of 4 community and 4 population parameters. Differences between the species richness of the malaise-trapped community, which collected 44 species with a mean of 22.2 species/site, and that of the netted community, which collected 44 species with a mean of 27.2

species/site, were not significant (PO.5,α8). Analysis of trapping data for species diversity, 2.34 for malaise vs. 1.30 for netting, and the species evenness, .08 and .40 for malaise and netting respectively, showed both were significantly different (P.01,α8). The community similarity index, .08, indicated that the structure of the tabanid community trapped by each method differed substantially. The relative densities of the species trapped by each method were significantly different for most *Chrysops* and the dominant *Tabanus* and *Hybomitra*, although a site × method interaction existed with *H. losiophthalmus*, *H. sodalis*, *T. lineola*, and *T. pumilus*, which statistically masked this significance. Though the seasonal ranges found by each trapping method did not closely coincide, the seasonal niche breadths were not significant except for 4 species: *H. sodalis* and *C. macquarti* (P.01,α8), *C. geminatus* and *T. lineola* (P.05,α8). Neither trapping method should be used alone in studies concerning the entire tabanid community but can be used effectively together.

Infecting the Gypsy Moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae) with Nuclear Polyhedrosis Virus Vectored by *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae)

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This study was undertaken to determine the ability of *Apanteles melanoscelus* (Ratzeburg) contaminated with nuclear polyhedrosis virus (NPV), to infect gypsy moth larvae and to determine the feasibility of using this method of virus dissemination as an alternative to topical foliar application. Three methods of contaminating the parasitoids with virus were tested. The first method involved exposing female parasitoids to first, second, and third-stage gypsy moth larvae that had been feeding on artificial diet containing 1×10^7 polyhedral inclusion bodies (PIB)/ml for a period of 48 hr. In the second method virus was applied directly to the ovipositor at a concentration of 1×10^9 PIB/ml. A topical application of virus at a concentration of 1×10^9 PIB/ml by means of an atomizer was the final method of contamination of parasitoids that was tested. Percent mortality due to virus was found to be higher among larvae exposed to contaminated female parasitoids than larvae that were exposed to uncontaminated female parasitoids and the transmission of virus does not appear to diminish with each successive sting. The most promising method of contaminating the parasitoids with NPV was found to be manual application of the virus to the ovipositor, however, none of the contamination techniques seemed to have any effect on the parasitoids.

Cassida rubiginosa Müller (Coleoptera: Chrysomelidae), a Potential Biocontrol Agent of Thistles in Virginia

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C. rubiginosa, accidentally introduced into North America and first reported in 1901, presently has a geographical range encompassing most of eastern North America north of central Virginia. During 1973 and 1974, life stages of the beetle were collected from 15 sites in the northern Virginia counties of Frederick, Clarke, and Warren. The purpose of this study was to isolate this beetle from a major obligate gregarious exotic larval and pupal endoparasitoid *Tetrastichus rhosaces* (Walker) (Hymenoptera: Eulophidae). Immature cassid life stages were reared to the adult stage and released 100 miles south of its southernmost range in the southwest counties of Montgomery and Giles. A total of 7840 adults were released at 9 sites with 3 replicates each for the three thistle species *Carduus nutans* (L.)—musk, *C. acanthoides* L.—plumeless, and *Cirsium arvense* (L.) Scop.—Canada thistle. In 1975, cassids were recovered from all release sites with Canada thistle sites having the highest rate of recovery followed by musk and plumeless thistles. Cassids dispersed less than 30m in any one direction from the release point at most sites. Periodic observations of cassid life stages at one musk and Canada thistle sites revealed only one possible case of parasitism, probably by the solitary facultative native parasitoid *Eucelatoriopsis dimmocki* (Aldrich) (Diptera: Tachinidae). Predation by spiders, assassin and stink bugs, chrysopids, and other arthropods was the major biotic mortality factor.

Growth Form of Host Plant as a Determinant of Feeding Efficiencies and Growth Rates in Papilionidae and Saturniidae (Lepidoptera)

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Larval growth performance of butterflies and moths was studied on leaves of their normal host plants to test whether specialized, stenophagous herbivores utilize their food resources more efficiently than do generalists. *Graphium marcellus*, *Battus polydamas*, *B. philenor*, *Papilio zelicaon*, and *P. polyxenes* are specialized primarily on one plant family. *P. palamedes*, *P. troilus*, and *P. multicaudatus* are intermediate (2 to 5 families), and *P. glaucus* is very generalized, feeding on at least 13 families. For both the penultimate and

final instars the efficiency of conversion of ingested food into larval biomass of the specialists was significantly higher than that of the intermediate and generalized species. Growth rates for specialized papilionids were more than twice as great as those for generalists. Among the swallowtail species the trend from specialized to generalized feeding paralleled a trend from herb-feeding to tree-feeding. No significant differences were found in feeding efficiencies of the final two instars of tree-feeding moths *A. pernyi*, *S. cynthia*, *C. angulifera*, and *B. mori* (specialized), *C. promethea*, *A. luna*, and *C. regalis* (intermediate), and *E. imperialis*, *H. cecropia*, *A. io*, and *A. polyphemus* (generalized). Growth rates were also nearly identical for specialists and generalists. Regardless of their degree of feeding specialization, tree-leaf feeding larvae of both butterflies and moths grew at lower rates than herb-feeders. This indicates that growth form of the host plant has at least as important effect on the overall ecology and life history of a papilionid or saturnid species as has the degree of feeding specialization of its larva.

Reproductive Diapause in *Notonecta undulata* (Say) (Hemiptera: Notonectidae)

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Notonecta undulata (Say) completes two generations annually in Connecticut. The first generation, produced by overwintered adults, reaches maturity in early July. The second generation of adults develops in late summer and early fall and enters reproductive diapause. The reproductive activity is regulated by photoperiod and temperature. Photoperiod seems to be more important than temperature. Over 75% of the females raised in the laboratory under a 15-hr photoperiod (LD) and 22°C oviposited within 21 days after adult emergence, while less than 25% of the females raised under a 12-hr photoperiod (SD) and 22°C oviposited. When half of the latter group were subsequently placed under LD conditions, 75% of the females commenced oviposition within 21 days. The remaining half of the SD group was continued under SD conditions and less than 25% of these commenced ovipositing during the next 30 days. Females reared under SD and LD conditions were vivisected and terminal oocytes measured. Females reared under both conditions had terminal oocytes measuring less than 0.4 mm upon emergence as adults. Within 3 weeks LD females attained an oocyte length of 1.7 mm while females reared under SD conditions rarely exceeded .9 mm. Oosorption was observed in the few SD females with terminal oocytes as long as 1.7 mm. Low temperatures tend to inhibit reproductive development. When *N. undulata* was reared under LD conditions but at 15°C, only 50% of the females oviposited within 7 weeks of adult emergence. Photoperiods under which nymphs are reared appear to have no effect on subsequent reproductive development of adults.

Environmental Control of Diapause in Three Species of North American Aedine Mosquitoes (Diptera: Culicidae)

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Environmental factors influencing diapause were studied under field and laboratory conditions for three species of North American aedine mosquitoes: *Aedes atlanticus* (Dyar and Knab), *A. canadensis* (Theobald) and *Psorophora ferox* (Humboldt). To detect naturally occurring diapause, soil samples were collected in forest depressions in eastern Maryland at five different times of the year: March, May, September, November and December. Samples were divided into two equal parts—one part was held under long photoperiod conditions, the other under short photoperiod conditions, both at 25°C. Portions of each sub-sample were flooded weekly for four weeks. The proportion of viable eggs which hatched upon flooding varied with the species, the time of year collected, and the length of time held under experimental conditions. The results indicate that all three species undergo embryonic diapause which is terminated only after exposure to chilling temperatures. Photoperiod does not appear to play a role in diapause termination. Prolonged exposure to moderate temperatures appears, in addition, to be a necessary antecedent to hatching in *A. atlanticus* and *A. ferox*. Experiments were conducted in the laboratory to determine the influence of photoperiod on induction of diapause. Results indicated that short photoperiod exposure of the developing embryo of *A. canadensis* induces diapause, whereas similar exposure of *P. ferox* females results in the oviposition of diapausing eggs.

An Improved Insect Pest Management Program on Sweet Corn in New Hampshire

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Three years of field research studies on the detection and control of the European corn borer *Ostrinia nubilalis* (Hübner) and the corn ear worm *Heliothis zea* (Boddie) on sweet corn demonstrated the feasibility of an improved

insect pest management program for New Hampshire. First brood European corn borer can be controlled using whorl-stage treatments of either a granular insecticide applied once or liquid sprays applied twice. Since the arrival time of the corn earworm's northern migration can vary from year to year (August 1 to September 1), early detection with light traps for moth flights and inspection of silks for newly laid eggs is used to alert growers to the necessity for spraying. In years when the earworm arrives late, considerable reduction in the use of insecticides and a resulting savings to the grower is realized. Small plot research comparing directed granular applications at planting time (soil applications) and at what stage with spray treatments indicates Dyfonate 10GK, carbofuran 10G, N-2596 10Gk, and Sandose 197 give acceptable economic control of the European corn borer. A comparison of granular treatments applied either directly into the whorl or as a broadcast indicates a slight loss in effectiveness as a broadcast but acceptable economic control.

Sequential Releases of *Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae) for the Biocontrol of *Carduus* Thistles

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Rhinocyllus conicus, an introduced thistle-head feeding weevil, which has been established on *Carduus* thistles in Virginia has shown more effective control of *Carduus nutans* (musk thistle) than of *Carduus acanthoides* (plumeless thistle). This is apparently due to better synchronization of overwintering weevil emergence in spring with bud development of musk thistles than with plumeless thistles. Sequential field releases of overwintered weevils on individually-caged thistles were conducted to investigate the advantages of extending the ovipositional period and improving synchronization of the weevil with thistle development. Each of the releases produced an initial surge in oviposition of progressively decreasing magnitude on both *Carduus* thistles. The later releases successfully extended the ovipositional period, but were less effective due to reduced fecundity. Weevils also suffered increased mortality during prolonged caging prior to release. Regular monitoring of egg deposition on the developing thistle blooms revealed that *R. conicus* preferred the earlier stages of musk thistle capitula. This was not evident on the plumeless thistles which had eggs equally distributed on the buds as well as the fully developed heads. Preference for earlier bloom stages resulted in higher survival of larvae on musk thistles than on plumeless thistles. Eggs deposited on the later stages of plumeless thistle blooms failed to complete development, and had high larval mortality because of the inadequate period for development.

Survival of Aestivating Adult *Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae) at Different Temperatures and Photophases

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Successful field establishment of *Rhinocyllus conicus*, an introduced weevil for the biological control of *Carduus* thistles, is best obtained by spring releases at the initial stages of thistle bud development. To insure an adequate supply of ovipositing weevils at the time of release, senescent infested thistle heads collected from an established site in Virginia were held for weevil emergence. The newly emergent, aestivating weevils were caged with thistle leaves, and/or thistle heads, or artificial diet. These were exposed to different thermoperiods ranging from 10°–32°C with either declining or constant photophases of 0–16 h to determine conditions optimum for their survival until the following spring. Day-night thermoperiods of 21°–15°C synchronized with short photophases resulted in relatively lower mortality than treatments of 26°–15°C, and 32°–15°C with similar photophases. Aestivating weevils survived better when caged with thistle leaves at constant temperatures of 10 or 15°C, and continuous darkness. Best survival was obtained for weevils placed on artificial diet subjected to photophase of 0 or 10 h at 10°C. Mortality rate increased at higher temperatures and longer photophases. In the absence of thistle leaves or artificial diet, no weevils survived the entire duration of the experiment (August through April of the following year); those weevils subjected to the higher temperatures of 26°C or 32°C did not survive beyond December.

Increased Gladiolus Spike Growth with Use of Certain Systemic Insecticides

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Previous aphid control experiments suggested that treatments with certain systemic insecticides might improve gladiolus growth. A replicated field experiment was conducted near Suffield, Connecticut in 1972 to test this hypothesis. The experimental area was divided into 60 5-ft.-long plots, each of which was planted with 10 corms of the gladiolus cultivar "Peter Pears". The following 10 treatments were replicated 6 times in a randomized complete block design: dimethoate 2EC, oxydemeton-methyl 2EC, carbofuran 4F, carbofuran

10G, pirimicarb 50WP, acephate 75S, disulfoton 15G, aldicarb 10G, oxamyl 10G, and untreated control. All materials were applied at 1 lb ai/acre. Two granular soil treatments and 3 foliar spray applications were made with the respective materials. No significant differences were detected in plant emergence or height 17 and 23 days, respectively, after planting. At peak bloom granular soil treatments of aldicarb, oxamyl, and disulfoton showed significant effects on gladiolus growth as indicated by increased plant heights, flowerhead lengths, and bud numbers. Cucumber mosaic virus disease-infected plants in both aldicarb and disulfoton-treated plots showed growth benefits. We conclude it may be possible for gladiolus growers to obtain both increased plant growth and flower production as well as insect control through utilization of aldicarb, disulfoton, or oxamyl as soil insecticides.

Evaluation and Control of a Nuisance Fly Problem (Diptera: Muscidae) at Monmouth Park Jockey Club, Oceanport, New Jersey

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Throughout the 1973 summer racing schedule, Monmouth Park personnel experienced an acute fly problem. In 1974, inspections of 10 randomly chosen horse barns made 3 times per week from July to October, revealed a predominance of house flies, *Musca domestica* (L.), and stable flies, *Stomoxys calcitrans* (L.), in addition to small numbers of Tabanidae. Potential breeding sites of the predominant species were manure pits, hay barns, horse corrals, horse stalls, grass clippings and beached tidal creek vegetation. Larvae or pupae occurred at all but the latter two sites. Of 92 samples, manure pits and hay barns yielded the highest proportion of house flies and stable flies per sample. Layers of moist, decayed hay or alfalfa in front of the hay barns were particularly productive of stable flies. Manure pits containing STAZ-DRI (horse bedding derived from sugar cane refuse), horse manure, or a combination of both, produced large numbers of house flies. Evaluations of ULV applications with a Cardinal 150 sprayer (Northeastern Associates), using formulations of 1% pyrethrins (Dubois Chemical Co.), 5% pyrethrins (Northeastern Associates), and 40% resmethrin (S.B. Penick & Co.) diluted 18 fl. oz./gal. with light mineral oil, showed the latter superior, though variable winds to 5 mph, cool morning temperatures, and lack of penetration into barns limited control. Proper disposal of manure and hay barn refuse remains the most practical and effective means of fly control.

Control of External Parasites on Cattle by Means of Dust Bags

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Dust bags have been used for approximately 15 years for the control of external parasites on cattle. When properly installed and maintained, use of this type of self-treatment device will result in near-complete control of horn flies, *Haematobia irritans* (L.), and cattle lice and will effectively reduce face fly *Musca autumnalis* (DeGeer) populations. Two recent tests with 5% fenthion in dust bags resulted in 41% and 60% reduction in cattle grub infestation. Numerous field tests have shown that forced use of dust bags will result in more effective insect control. A shelter should be provided for any dust bags that are not water repellent. However, some good water repellent bags are now available from commercial sources. Protection from rainfall is necessary to prevent caking of the dust. To obtain the most effective face fly control, bags must be suspended within 18 to 24 inches from the ground. The efficacy of insect control is also enhanced when the bag swings freely so that as the animals pass under them they will bump the bags with their heads and again with their shoulders, thereby insuring a more thorough dust coverage of the head and body.

Wing Polymorphism in Salt Marsh Inhabiting Fulgoroidea

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The vegetation of New Jersey tidal salt marshes is composed primarily of two grasses, *Spartina alterniflora* Lois. (Smooth Cordgrass) and *Spartina patens* (Ait.) Muhl. (Salt Meadow Cordgrass). *S. patens* occupies a narrow elevational zone of well drained marsh above mean high water level (MHW). *S. alterniflora*, an intertidal species, occurs throughout most of the elevational range of *S. patens*, but also extends to levels far below MHW. Near MHW, where the marsh is flat and poorly drained, *S. alterniflora* occurs as a dwarfed form, but along depressed borders of creeks well below MHW, it may grow to the height of 2m. Structurally (culm height, width, density), *S. alterniflora* is more diverse than *S. patens* and ecologically occupies a more extensive elevational range which receives frequent tidal inundations. Fulgoroids, dimorphic for wing length, feed upon these salt marsh grasses. The purpose of this work was to investigate the ecological significance of wing polymorphism strategies employed by the fulgorids to cope with the structural variability and stability of food resources. The delphacid, *Prokelisia marginata* (Van Duzee), which is host specific on *S. alterniflora*, produced highly vagile macropters and brachypters with less efficient flight capability. In short form *S. alterniflora*, macropters and brachypters were sweep-netted in equal numbers. The following commonalities were evident for *S. patens* inhabiting fulgoroids [*Delphacodes detecta* (Van Duzee), *Tumidagena minuta* McDermott, *Aphelonema simplex* Uhler]: Brachyptery was extreme, preventing flight. Brachypters significantly outnumbered macropters. The density of brachypters correlated well with the seasonal pattern of standing crop biomass of the food resource. Macropter density was poorly correlated with standing crop biomass; however, seasonal macropter density occurred just prior to peak standing crop biomass of the grass. On the high marsh, which is less subject to tidal inundation and is occupied by a structurally monotonous food resource, fulgoroids have evolved a brachypterous strategy. On the intertidal marsh, where the food resource is structurally diverse and occasionally unavailable (tidal inundation), population mobility is at a premium and fulgoroids have evolved a strategy relatively skewed toward the production of macropters in order to efficiently exploit resources.

Isolation and Identification of *Entomophthora* spp. Fres. (*Phycomycetes*: *Entomophthorales*) from the Spruce Budworm *Choristoneura fumiferana* Clem. (Lepidoptera: Tortricidae)

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Entomophthora sphaerosperma Fres. and *E. egressa* MacLeod and Tyrrell were isolated from field-collected spruce budworm in Aroostook and Washington counties, Maine. An 18″ branch tip was taken from the upper and lower crowns of 5 trees at each of 13 locations. Living larvae were reared on artificial diet to determine disease prevalence. Fungi from diseased larvae were isolated on egg yolk plus Sabouraud maltose agar medium and then identified. Both species were tested for growth on several media and over a range of pH and temperature levels. Prevalence of infection was greater in the lower crown (7.4% *vs.* 2.6%) with an overall prevalence of 5.0% (90% level of significance). The conidia of *E. sphaerosperma* are slender, papillate at the base, rounded and tapered at the apex; 19.50 ± 2.14 μ × 7.64 ± 1.06 μ (Mean ± Standard deviation) from larvae, and 22.43 ± 4.90 μ × 7.24 ± 0.46 μ from specimens grown on artificial media. Conidiophores are branched and digitate. Rhizoids, secondary conidia and cystidia are present. Resting spores are hyaline, spherical and measure 24.90 μ ± 2.18 μ from larvae, and 26.30 μ ± 2.71 μ from media-reared specimens. The conidia of *E. egressa* are obovate to pyriform with a broad papillate base and an evenly rounded apex. They measure 38.56 ± 8.33 μ × 31.59 ± 7.26 μ, and are multinucleate (8–10). Conidiophores are branched. Resting spores, secondary conidia, rhizoids and cystidia were not observed. Mycophil yeast agar (MYA) at 20°C was found to produce the best growth of *E. sphaerosperma*. MYA at 20°C was then tested at a pH range of 5.0–7.5 at intervals of .5. Mycelial growth was predominant above pH 6.5, while abundant conidia production occurred below pH 6.0. Growth of *E. sphaerosperma* was also tested in shaker cultures on liquid media with Sabouraud liquid broth (SLB) within the range 5.5–8.0 pH and 25°C giving the best growth. Optimum growing conditions for *E. egressa* as determined in a like manner, were at 25°C on AK agar throughout a pH range 6.0 to 7.5.

A Sex Pheromone Complex of the Mushroom-Infesting Sciarid Fly, *Lycoriella mali* Fitch

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The sex pheromone complex of the sciarid fly, *Lycoriella mali* Fitch consists of a homolog series of saturated, straight chain, aliphatic hydrocarbons. Sciarid males are attracted to hydrocarbons pentadecane to hexacosane and octacosane (C_{15}–C_{26},C_{28}) when tested in a biological assay chamber. Heptadecane is the most active hydrocarbon. In addition, statistical testing of heptadecane and neighboring hydrocarbons (C_{15}–C_{19}) support this finding. Concentration studies of heptadecane show that the best overall response (80%) and the best attractive response (79%) occur at the 1.0 nanogram level. Abdomens of culture males and females were analyzed for the presence of hydrocarbons pentadecane to octadecane. Isolation and identification of hydrocarbons was accomplished by thin layer chromatography, gas chromatography and computerized gas chromatography-mass spectrometry with mass fragmentography. Hydrocarbons (C_{15}–C_{18}) were found in both male and female abdomens. Female abdomens had greater concentrations of these hydrocarbons than male abdomens. The major attractant, heptadecane, was found in the female sciarids at a concentration of 5–6 times larger than found in the male sciarids. Recent results from our laboratory have shown that some lepidopteran and hymenopteran pheromones are present in the host plant. Therefore, the cultivated mushroom, *Agaricus bisporus* Lange was analyzed for hydrocarbons. Hydrocarbons pentadecane to heneitriacontane were identified and their relative concentrations determined. It has been shown that the sex pheromone of the sciarid fly is not a single component but a complex mixture. Host plants are implicated as a possible origin of the pheromones.

Results of an Insect Scouting Program in Virginia Soybeans

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After 2 years of monitoring insect control decision-making practices in eastern Virginia, 2 test demonstrations were undertaken to encourage adoption of a pest management system. Unlike the 2 previous studies, a vigorous educational program was conducted with farmers. Mean per acre scouting costs were higher in both counties (Isle of Wight $0.52; Westmoreland $0.59) than in previous years, reflecting higher labor costs and a difference in scouting efficiency. Due to a change in objectives, it was not possible to measure the potential saving or net return on investment as in past years. Premature insecticide application was reduced from 87.2% in 1972 and 89.7% in 1973 to 0% in 1974. In addition to the demonstrations mentioned above, the first grower-financed scouting service in Virginia was adopted in Northumberland and Lancaster counties in 1974. The program included 11 farmers and 43 fields. A subjective evaluation conducted at the conclusion of the program showed the following results. Most farmers (72.9%) estimated that they saved $4.98/acre using the scouting system. Only 8.3% of the farmers thought yields were reduced; 85% of the farmers said they would subscribe to a scouting service on a "pay as you go" basis in 1975 if it were available but only 62.5% said they would use the system if they had to do the scouting themselves. The overall response indicated grower approval.

Leaf Feeding Resistance to the European Corn Borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae), in Tropical Maize

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First generation or leaf-feeding resistance of maize to the European corn borer has generally been attributed to 2,4-dihydroxy-7-methoxy (2H)-benzoxazin-3 (4H)-one (DIMBOA), an aglycone that suppresses larval development and increases larval mortality. Tropical maize genotypes as low in DIMBOA as the susceptible inbred WF9, have been shown to be as resistant to leaf feeding in field trials, as high-DIMBOA inbreds. We studied leaf feeding activity of 1st instar *O. nubilalis* on 3 inbred (WF9, B68, B49) and 2 tropical (6006: San Juan-3 × Antigua-8D; 6008: Puerto Rico-1 × Antigua-2) genotypes using free-choice and no-choice laboratory caging methods, to determine the resistance mechanisms. Using no-choice Plexiglas® tube cages or dialysis tube cages on rolled leaves, feeding rates at 12 hr intervals over a 60 hr post-caging observation period, were consistently reduced on the high DIMBOA inbred, B49, and on the tropical genotype, 6006, as compared to a susceptible inbred, WF9. Feeding was intermediately reduced on 6008 and B68, compared to WF9. When given a choice between 2 genotypes, larvae consistently preferred WF9 over the other 4 genotypes. Thus, we concluded that feeding suppression of *O. nubilalis* during the 1st stadium is probably a significant component of resistance in field-resistant tropical and inbred genotypes. Moreover, suppression of larval leaf feeding by the tropical lines, 6006 and 6008, is mediated by plant factors other than DIMBOA.

Visual Stimuli in the Host Finding Mechanism of the Parasitic Wasp *Itoplectis conquisitor* (Say) (Hymenoptera: Ichneumonidae)

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An investigation into the kinds of visual cues utilized by *I. conquisitor* during host finding was conducted by measuring attraction, discrimination (antennal tapping) and acceptance (probing) responses to various host and host-shelter models. To demonstrate the presence of a visual attractive stimulus, wasps were tested with sealed glass cylinders each containing a dead host pupa near one end. The other end, which remained empty, served as a control. The number of attractions to the pupa containing side was found to be significantly greater than to the empty end of the same tubes. No discriminatory behavior was elicited by these glass models. A further elucidation of visual stimuli was accomplished using construction paper and cellophane models which differed in shape and degree of transparency. All opaque models were found to be superior to their transparent counterparts in visual attracting capability. Moreover, all cylindrical models were superior to their flat counterparts in this property. With regard to discriminatory and acceptance responses, however, only cylindrical shapes appeared to be of any significant importance. The possibility that a host finding mechanism other than of a chemical nature is in operation was confirmed by the following experiment. Newly emerged females with no ovipositional experience were individually isolated for 7 days

in a chemically clean environment. After this isolation period, the wasps were released into glass beakers containing aluminum foil cylinders and their responses were recorded. Typically, the wasps showed aggressive discriminatory and acceptance behavior in less than 1 hour of testing.

Dispersal of First-Instar Gypsy Moth Larvae in Relation to Population Quality

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Investigations by D. E. Leonard indicated that the behavioral and physiological ecology of the gypsy moth, *Porthetria dispar* (L.), varied with the size of the eggs from which the larvae originated. Also, the ecological patterns could be shifted by certain environmental stimuli. This principle was termed population quality. Leonard suggested that dispersal was the most important parameter affected. Our investigation examined the effect of population quality on dispersal by first-instar larvae. Eggs deposited by the female gypsy moth vary in size. The first eggs deposited are largest in diameter and subsequent eggs are smaller. Laboratory dispersal studies indicate that larger eggs produce larvae that disperse more frequently than larvae from smaller eggs. However, small larvae unable to locate adequate food will disperse as frequently as large larvae. Dispersal ability of larvae declines rapidly as larvae feed and become heavier. Except at low wind velocities (less than .9 m/s), large larvae disperse greater distances than small larvae. Egg size is inversely proportional to the number of eggs per mass. Factors favoring development of large adults will induce large egg masses and lead to populations of non-dispersing larvae. Failure of large numbers of larvae to disperse from a site can lead to localized population outbreaks. In turn, high density populations produce small egg masses which produce relatively more dispersing larvae, thereby providing the inoculum for new outlying infestations.

Identification of the Copulatory Sex Pheromone of the Little House Fly, *Fannia canicularis* (L.) (Diptera: Muscidae)

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A sex pheromone that stimulates *F. canicularis* males to copulate with females was identified as (Z)-9-pentacosene. Cuticular lipids obtained from virgin 5-day-old female flies were used for the isolation of the active compound.

Materials were bioassayed by counting the number of copulatory attempts that occurred during a 5-minute period when pseudoflies constructed from knots of black yarn were treated with 100 or 200 μg of the test material and presented to unmated males. Isolation, identification, and synthesis procedures were similar to those reported by Uebel et al. in 1975 (J. Chem. Ecol. 1: 195–202). All major materials in the female cuticular lipid are hydrocarbons. The major components of the unsaturated hydrocarbon are (*Z*)-9-pentacosene and (*Z*)-9-heptacosene, which make up 66.5 and 3.4% of the cuticular lipid, respectively. Approximately 25% of the cuticular lipid is straight chain saturated hydrocarbon, and 4% is branched chain saturated hydrocarbon. Five-day-old males have a "non-hydrocarbon" that makes up 27% of the total cuticular lipid. Approximately 27% of the male cuticular lipid is straight chain paraffin, 20% is branched saturated hydrocarbon, and 19% is unsaturated hydrocarbon. The pentacosene present on the male constitutes 7% of the cuticular lipid and is present as two isomers: (*Z*)-9-pentacosene (5%) and (*Z*)-7-pentacosene (95%). Only fractions containing the unsaturated hydrocarbon from the female stimulated the males to copulate, and tests with the two synthetic monoolefins found on the female showed that only (*Z*)-9-pentacosene was active.

Honeylocust Pod Gall Midge, *Dasyneura gleditschae* Osten Sachen (Diptera: Cecidomyiidae), Control with Dacamox®

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Increased planting of thornless honeylocust as street and shade trees and nursery production of popular varieties in large blocks has intensified problems caused by the honeylocust pod gall midge. Three varieties (Shademaster, Sunburst, and Skyline) of thornless honeylocust were side dressed with systemic insecticides on May 1 & 2, 1975 at rates of ozAI per 1000 ft. of row as follows: aldicarb 7.2 and 14.4, carbofuran- 4.4 and 8.8, disulfoton- 22.5 and 45, acephate- 6.0 and 12, and Dacamox® (3,3- Dimethyl- 1- methylthio- 2 butanone 0-methylcarbamoyloxime)- 6.0 and 12. The soil, a sandy loam with good field moisture, was cultivated just prior to treatment. It rained immediately after treatment. The granules were applied in a 2-in.-wide band and covered with ca. ½ in. of soil. Counts made June 17, 1975 of the number of galls on 10 shoots (each shoot had 5–10 leaves with ca. 20 leaflets per leaf) on each of 5 trees from the center of each plot indicated that only Dacamox showed promise of giving economically practical protection. Dacamox, at the high rate, reduced the number of leaf galls on the different varieties as follows: Shademaster 82%, Sunburst 50%, Skyline 71%. Percent defoliation estimated on July 23, 1975 for Dacamox vs. check, respectively, was: Shademaster 40% vs. 53%, Sunburst 17% vs. 52%, Skyline 32% vs. 54%. None of 13 toxicants applied May 2, 1975 as hydraulic sprays gave economically effective protection.

A Seasonal History of the Variegated Leafroller, *Platynota flavedana* Clemens (Lepidoptera: Tortricidae), in Virginia Apple Orchards

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The variegated leafroller overwinters as dormant larvae in leaf litter on the apple orchard floor. In early March larvae feed on ground cover sprouts and apple root suckers. Spring moths begin emerging in early May and are present in orchards until early July. Egg masses are laid on upper sides of apple leaves from May to July and again in late July to September. A fecundity study of 21 second generation females indicates an average of 205.7 eggs per female with 53.4 eggs per mass and 91.8% hatch. The incubation period averages 12.8 days for first generation eggs and 9.3 days for the second. Study of 154 individuals shows that most first generation larvae have 5 instars; however, some have an occasional sixth. The average time for larval development is 29.8 days. The pupal period averages 6.5 days. First generation moths begin emerging the third week of July and are present in orchards until mid-September. The life cycle averages 42.4 days for the males and 47.1 days for the females. Fruit is damaged toward summer's end and early fall by late instar larvae of the first generation and younger larvae of the following generation. These second generation leafrollers reduce their activity but continue feeding through early November. When autumn leaves fall the larvae range from second to fourth instar. In 1974 at Winchester, Virginia there occurred the end of the overwintering generation, one complete generation, and the beginning of a second generation of *P. flavedana*.

The Milkweed Pod as an Obstacle to the Large Milkweed Bug, *Oncopeltus fasciatus* (Heteroptera: Lygaeidae)

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In the eastern United States *Asclepias syriaca* is a common host of the monophagous *Oncopeltus*. In greenhouse experiments nymphs fed only vegetative shoots of *A. syriaca* could not grow or mature, but those provided *A. syriaca* seeds readily did. In the field adults and nymphs feed almost exclusively on pods. However, measurements of nymph mouthparts, feeding punctures, and the spongy pod walls showed that the mouthparts of the first three nymphal instars are too short to reach seed in most mature pods. By exploring, these young nymphs sometimes find sites with thin walls where they can reach the seed. Usually they live on poorer food tapped from the green tissues and placenta of the pod. Communal feeding may be especially important during this stage in increasing food intake. Thus *Oncopeltus* can exploit this milkweed, even though the bug's critical food, the seed, is inaccessible to the young nymphs. Although adults and fifth instar nymphs can reach seed through almost any pod wall, many seeds escape *Oncopeltus* damage because pods are abundant and the bugs preferentially feed where the pod wall is thinnest, on the seeds nearest the suture and the tip.

Growth and Development of *Hyposoter exiguae* (Viereck) (Hymenoptera: Ichneumonidae) on Two Instars of *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae)

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Larvae of *Trichoplusia ni* (Hübner) were parasitized during phase II of either their 2nd or 4th instar by the solitary endoparasitoid, *Hyposoter exiguae* (Viereck). Beginning at 36 hr post-parasitism and continuing at 8 hr intervals thereafter, hosts were dissected and measurements of the contained parasitoid taken. *Hyposoter* larvae eclosed from eggs between 36 and 44 hr post-parasitism in both 2nd and 4th instar hosts. Four larval instars were observed, the first lasting about 2 days, the 2nd and 3rd lasting 1½ days and the 4th less than 1 day. Parasitoid head capsule widths measured 0.15, 0.34, 0.51 and 0.61 mm for those reared on 2nd instar hosts, and 0.15, 0.35, 0.54 and 0.67 mm for those reared on 4th instar hosts. Parasitoids reared on 4th instar hosts emerged to spin their cocoons between 6½ and 7½ days post-parasitism at 26 ± 1°C, while those reared on 2nd instar hosts emerged a few hr later. Parasitoid adults reared on both age groups emerged 6–7 days after spinning. Adult parasitoids reared from 2nd instar hosts weighed 4.81 and 5.17 mg for males and females, respectively, while those reared from 4th instar hosts weighed 6.25 and 6.91 mg. Since host age has been shown to affect parasitoid size and developmental rate, it is important that it be taken into account when performing experiments on parasitoid fecundity, fertility and development. Otherwise a wide range of values may occur for these parameters.

Mite Consuming Capacity of *Stethorus punctum* (Leconte) (Coleoptera: Coccinellidae)

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The functional response of the predator *Stethorus punctum* (Leconte) was tested at various densities of the European red mite, *Panonychus ulmi* (Koch). One *S. punctum* adult or larva was caged with adult female mites at the following density levels: 4, 8, 12, 16, 20, 50, 80 mites/cage. The number of mites consumed was recorded every hour and the mites replenished back to the original levels. All feeding tests were conducted in a screened insectary to simulate orchard conditions. The rate of consumption of overwintered adults (spring feeding rate) rose at first with prey density, but leveled off at higher densities. The rate of consumption of the 2nd and 3rd generation adults (summer feeding rate) increased with increasing prey density with no leveling off attained. *S. punctum* larvae also exhibited an increased consumption rate as prey density was increased. At the lower density levels the larval feeding rate was higher than for male adults. As prey density increased beyond 20 mites/cage the adults were able to consume more mites. *S. punctum* adults and larvae stop feeding at dusk and resume feeding ca. 2 hrs. after sunrise. The ability of *S. punctum* to functionally respond to increasing prey density plays an important role in keeping the European red mite below economic injury levels in Pennsylvania.

The Influence of a Juvenile Hormone Mimic (JHM) on *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae) and *Hyposoter exiguae* (Viereck) (Hymenoptera: Ichneumonidae)

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The influence of Altozar®, a juvenile hormone mimic (JHM), on parasitized and unparasitized cabbage looper, *Trichoplusia ni* (Hübner), was studied. Parasitized and unparasitized *T. ni* larvae were reared on standard wheat germ diet until early 4th instar then on diet containing 0.1, 1, 2 and 4 ppm of Altozar. Larval development was essentially the same on all treatments from the 4th to the 5th instar. The 1, 2 and 4 ppm treatments of the JHM had a decided influence on the development of the unparasitized 5th stage larvae. Individuals on diet containing the higher dosages remained in the larval stage

up to 2 weeks longer than the controls and 0.1 treatment. Approximately 75% of these began a supernumerary molt into a 6th instar, but none of them pupated. About 20% of the remainder pupated. No adults were obtained from 2 and 4 ppm treatments and 2.5% from the 1 ppm treatment. *T. ni* larvae parasitized by *Hyposoter exiguae* (Viereck) developed the same on JHM and control diets. Parasitoids emerged from hosts on both diets at the same time and immediately began to spin cocoons. When JHM was topically applied at 2 and 20 μg prior to parasitoid emergence, development was extended and adult mortality ranged from 5 to 95%. JHM generally disrupts insect development prior to the larval pupal molt. Since the parasitoids' last larval molt occurs after the host ceased feeding, apparently insufficient JHM is available to influence parasitoid development. Topical application of the JHM nearing the time of parasitoid emergence allows sufficient material to reach the parasitoid and influence development. Thus the developmental pattern of a beneficial insect must be known in order to determine the impact of a JHM.

Response of the Alfalfa Weevil Parasitoid, *Microctonus colesi* (Drea) (Hymenoptera: Braconidae), to a Recommended Insecticide Treatment in Pennsylvania

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Studies were conducted from 1971 to 1974 to determine the impact of recommended insecticide treatments on *Microctonus colesi*, a parasitoid of the alfalfa weevil, *Hypera postica* (Gyll) (Coleoptera: Curculionidae). Two adjacent multifarm complexes were chosen for the study. Methyl parathion was applied on all fields in one region in accordance with the recommended threshold level of 50 to 75% alfalfa tip injury or 2 wk before normal first crop harvest date. Alfalfa weevil and *M. colesi* populations were monitored weekly in 10 fields in each region during first crop growth. Immediate impact of a first crop spray of methyl parathion at ½ lb AI/acre 2 wk preharvest was a substantial reduction in both parasitoid and host populations in each of the 3 years of application, 1971–1973. *M. colesi* larvae in the adult weevils were the most prevalent stages of the parasitoid at the time of spraying. The impact on *M. colesi* in the adult weevils was obvious as the sprayed area contained in excess of 98% fewer adult weevils than the non-sprayed area one week post spray in each of the 3 spray years. Consequently, each spray year a significant reduction in the *M. colesi* larval population in adult weevils was observed in the sprayed region. *M. colesi* adults and immatures in weevil larvae had just begun to materialize in the parasitoid population when the spray was applied. However, any postspray decline in adult *M. colesi* in the sprayed area resulted indirectly from earlier mortality of adult weevils harboring these parasitoids. *M. colesi* larvae in host larvae were not influenced by the spray. Their reduced numbers in the sprayed area resulted from few adult *M. colesi* available for parasitization and fewer host larvae available to be parasitized. Better coordination of insecticide sprays and *M. colesi* development is essential if *M. colesi* is to realize its maximum potential in Pennsylvania.

Determination of Seasonal Activity of Four Fruit Pests Using Pheromone and Other Traps

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Pheromone traps were used for three successive seasons (1972–74) to determine activity peaks of codling moth *Laspeyresia pomonella* (L.), red-banded leafroller *Argyrotaenia velutinana* (Walker) and oriental fruit moth *Grapholitha molesta* (Busck) while traps combining attractive baits and colors were used to capture apple maggot *Rhagoletis pomonella* (Walsh) flies in sprayed and unsprayed apple trees. Oriental fruit moth, codling moth and apple maggot were more abundant in unsprayed than in sprayed apple trees. Red-banded leafroller was as abundant or more abundant in sprayed than unsprayed trees. Oriental fruit moth was captured over a period of 20 weeks with 3 activity peaks occurring in May, July and September. Capture of red-banded leafroller indicated 3 activity peaks for male moths occurring during a 22-week emergence period. Emergence and peaks of first generation moths occurred one month earlier in 1974 than in 1972. Codling moth adults were active over a 16-week period with 2 peaks in early June and August. Apple maggots emerged over a 9-week period with a single peak occurring in mid-July or early August. Comparison of activity peaks of these moths over a 3-year period with spray intervals currently being used in Connecticut orchards indicated that modifications could be made using alternate middle row or extended interval spraying to reduce pesticide use while controlling the apple orchard pests. A reduced spray program in 1973 and 1974 resulted in less than 1.0% fruit damage by these pests.

Depth Selection in *Buenoa* (Heteroptera: Notonectidae)

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The coexistence of similar species depends on the division of resources. While resource sharing between sympatric congeneric species has attracted much attention, little information exists on how species of *Buenoa* coexist. This study documents micro-habitat separation in *B. margaritacea* and *B. confusa* by selection of different swimming depths. *Buenoa confusa* swims closer to the surface than *B. margaritacea.* Generally, nymphs of these species swim deeper as they mature. The duration of a dive changes ontogenetically and differs between species in a manner similar to that of swimming depth. The two phenomena seem related. It is proposed that swimming depth and dive duration depend on the amount of hemoglobin carried rather than physical gill efficiency. Selection of the depth of water for swimming (as opposed to swimming depth below the surface) differs between life-history stages and species. Nymphs and species that swim closer to the surface enter shallow water more often. Swimming depth affects prey selection. In shallow water (12cm) both species prefer the same prey (*Daphnia*). In deep water (28cm) prey selection differs, with each predator preferring prey items in its preferred depth range.

Rearing the European Corn Borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae) on a Lima Bean Medium

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Our attempts (1971–72) to rear European corn borer, *Ostrinia nubilalis* (Hübner), collected in southern Delaware, on the meridic diet used at the Corn Borer Investigations Laboratory, Ankeny, Iowa, were unsuccessful. With modifications, an oligidic diet, previously used to rear cabbage looper, *Trichoplusia ni* (Hübner), has proven highly satisfactory. The primary ingredient is dried "baby" lima beans. Brewer's yeast, agar, methyl *p-hydroxybenzoate*, ascorbic acid, Fumidil B, formaldehyde (37%), and distilled water constitute the remainder of the diet. The larvae are reared at LD 15:9, 30°C and 20°C, respectively. The following characterizes the colony under routine rearing conditions. Egg viability averages over 90%. Eighty-one percent of the larvae pupate in corrugated cardboard rolls above the media. Adult emergence averages 91%. Individual females lay an average of 22.1 egg masses (ca. 20 eggs/

mass) over a period of 12.5 days. A comparison of the first seven generations of a colony started in 1974 with the last seven generations (i.e. F26–F32) of a colony started in 1971 showed no significant ($p = .05$) difference in number of egg masses produced per female. Larvae, from one colony, were tested for survival on corn plants after 20 and 30 laboratory generations. Results indicate no difference in survival as compared to "wild" borers. Diapause induction and termination studies showed no significant ($p = .05$) difference between a colony reared for 31 generations and a colony reared for five generations.

Application of Harmonic Analysis and Polynomial Regression to Study Flight Activity of *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae) in the Field

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Counts of male and female budworm moths captured in aerial Malaise traps were obtained every hr continuously for 1344 trap hrs over 14 days of study. Captures averaged 12.6/h and 4.4/h and ranged from 0 to 183/h and from 0 to 82/h per trap respectively for males and females. Harmonic analysis showed the circadian rhythm of male activity could be described by $P_t = 12.560 - 11.431 \operatorname{Cos}(2\pi t/24) - 6.156 \operatorname{Sin}(2\pi t/24) + 5.273 \operatorname{Cos}(4\pi t/24) + 6.199 \operatorname{Sin}(4\pi t/24)$ and the circadian rhythm of female activity by $P_t = 4.438 - 5.789 \operatorname{Cos}(2\pi t/24) - 0.558 \operatorname{Sin}(2\pi t/24) + 3.598 \operatorname{Cos}(4\pi t/24) + 0.941 \operatorname{Sin}(4\pi t/24)$ where P_t is the mean number of captures in the hr interval and $t = 0$ corresponds to 0800 EDST (and $t = 0, 1, 2, \ldots, 23$). Peak activity occurs at 2152 EDST and 2021 EDST respectively for males and females. The amplitude of male activity is ca. twice that of the female. Polynomial stepwise regression of residuals ($r_t = P_t - Y_t$) vs weather identified intercorrelated variables influencing activity. A study of partial derivatives with respect to weather variables showed complex interactions with humidity, cloudiness, rainfall, wind velocity, and barometric pressure change. Males and females differed considerably in their response. Circadian rhythms are interpreted as gross adjustments to average environmental conditions; and reaction to weather is interpreted as fine adjustments of the population to specific environmental conditions.

Mosquito Control in Unusual Breeding Sites in Southern Italy (Diptera: Culicidae)

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Mosquito problems in the Mediterranean area are characteristically influenced by both climate and culture. Irregular rainy periods have resulted in the use of a variety of cisterns, irrigation systems (often aqueducts) and catchment areas for water storage during dry periods. Unusual mosquito breeding sites are found in many buildings, caves and temples, commonly referred to as "ancient ruins." In some instances, some of these "ancient ruins" have become altered by age or partly sunken over long periods of time due to nearby geological activity causing the formation of lakes, ponds and slow-moving streams, all which have become ideal mosquito breeding sites. Because so many of the mosquito breeding sites are contained within historical landmarks, mere access to them often requires significant effort. Conventional remedial means such as draining, filling or spraying with insecticide would be imprudent, contaminating, or impractical. Use of mosquito fish, *Gambusia affinis* has been useful in resolving some of the mosquito breeding site problems. In the many elaborate irrigation systems, mosquito breeding sites coexist with water wastage or poorly managed water. Increasing cost of water for irrigation has done much to mitigate this problem.

Temefos Residues in the Salt Marsh Snail *Melampus bidentatus* Say (Bassommatophora: Ellobiidae)

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Uptake of the mosquito larvicide temefos by populations of the salt marsh snail *Melampus bidentatus* in the field was measured by gas chromatographic analysis. Snails exposed in the field to temefos treatments as applied in normal mosquito control work were placed on ice and taken to the laboratory for analysis. Temefos was extracted in dichloromethane and cleanup was performed with hexane and acetonitrile. Uptake of measurable levels of temefos occurred within one day after the first treatment of a 2% granular formulation. A longer period of time, 3 weeks, elapsed before uptake following treatment with a temefos emulsion. Residues in samples of snails exposed to the granular formulation were generally around 1 ppm, with residues measured as high as 8.75 ppm in one sample. Residues were considerably lower in snails exposed to the emulsion. The highest residue was 0.059 ppm in this case. Residues in snails exposed to the emulsion fell below detectable levels in less than 3 weeks following cessation of treatments, while measurable amounts were found in snails exposed to the granular formulation for more than 5 weeks after the last treatment. Detection of temefos in *M. bidentatus* for such long periods suggests the potential for movement of this insecticide through food webs exposed to the granular formulation.

Bionomics of the Tufted Apple Budmoth, *Platynota idaeusalis* (Walker) (Lepidoptera: Tortricidae), in Pennsylvania Apple Orchards

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P. idaeusalis is a leafroller which is a major pest of apple in Pennsylvania and areas to the south. Larvae consume tissue from leaves and the surface of fruit. Larvae are difficult to control with insecticides because many are hidden in protected places which spray does not reach. There are two broods annually with second brood larvae overwintering. Eggs are laid on the upper surface of apple leaves in flat green masses which contain an average of 70 to 80 eggs. Eggs for the first brood are laid during June and the first half of July. First brood larvae develop during June and July, and some even into August. Eggs for the second brood are laid during August and September. Second brood larvae do more damage to apples because they are more numerous and the apples are larger. Also, growers tend to terminate insecticide applications too early to protect fruit from all larvae. Larval feeding on apples is finally ended by the harvesting of the fruit. Larvae of all instars overwinter in leaf litter under trees; they do not diapause, and may feed on ground vegetation whenever the temperature is high enough to permit activity. Natural biological control agents include some hymenopterous parasites of eggs and larvae, a tachinid parasite of larvae, some virus diseases, and probably some predators. A synthetic sex attractant may be used to detect male moths and monitor their seasonal flight periods.

Parasitization of the spruce budworm, *Choristoneura fumiferana* (Clemens) (Lepidoptera: Tortricidae) by *Brachymeria intermedia* (Nees) (Hymenoptera: Chalcididae)

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The introduced parasitoid *Brachymeria intermedia* attacks the gypsy moth in Maine, and laboratory studies (Minot and Leonard, p. 269) show that it will parasitize spruce budworm pupae. No recoveries were made in spruce budworms after limited field releases of this parasitoid in mature stands of spruce and balsam fir in 1973 and 1974. To facilitate observations and sampling, the 1975 release was made in a spruce budworm infested 2 ha plantation of 3 to 5 m white spruce in Shin Pond, ME. On 23 Jun, when 35% of the budworm had pupated, 14,000 *B. intermedia* were released along a 28 m transect. The weather during the period of spruce budworm pupation and adult emergence was warm, with highs in the 33°C range, and clear or partially cloudy days. Activity of the released parasitoids was assessed by counting the number of adults observed in 10 min searching of trees in the area of release. Parasitism was determined by collecting and rearing 5453 spruce budworm pupae in the release area, and 2743 pupae in trees 10 to 20 m from the release points. Two days after release, *B. intermedia* were observed up to 74 m from the nearest release site, but most adults were observed in or immediately adjacent to the release area, flying about the tree terminals and occasionally landing. Ten min counts of parasitoids between 24 Jun and 2 Jul ranged from 1 to 53, with the lowest counts in the morning between 0830 and 1030 hr. In the release area, 18.2% of the spruce budworm pupae yielded *B. intermedia* adults, and in the adjacent area, 11.7%. The percentage mortality is considerably higher than the total native pupal parasitoid complex. The sex ratio of the recovered parasitoids favored males by 3:1, and may be related to the smaller size and limited food reserves of the host pupae. This aspect is currently being studied.

Influence of Physical Factors on the Behavior and Development of *Brachymeria intermedia* (Nees) (Hymenoptera: Chalcididae)

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B. intermedia is a polyphagous endoparasite of Lepidoptera pupae. This primary, solitary parasitoid has been successfully introduced into gypsy moth populations in North America. This study tested the response of the parasitoid to physical factors and developmental rates in gypsy moth pupae at different temperatures. Adult parasitoids were exposed to a temperature gradient that ranged from 22° to 31°C. They were exposed to a humidity gradient that ranged from 11% to 90% relative humidity. Geotactic, phototactic and olfactory reactions, and diel periodicity were also investigated. *B. intermedia* preferred temperatures between 26.5° and 28.5° and preferred the dry end of the humidity gradient. They were positively phototactic and inactive in the dark. No geotactic or olfactory responses were detected. They were most active between 1300 and 1700 hr. There was considerable unexplained mortality among pupae exposed to the parasitoid. The same number of hosts were killed at all 3 developmental temperatures, but twice the number of *B. intermedia* emerged at 28° as at 23°. At 18° only 3 parasitoids emerged from 120 exposed pupae. These experiments confirm field observations of several workers that *B. intermedia* is attracted to a warm, dry physical environment subjected to high lux. Adults are most active in the afternoon when the above conditions are more likely to be encountered. Development is most rapid and successful at the highest temperature investigated, 28°.

The Use of Autoradiography to Detect RNA in Polyhedral Inclusion Bodies of Insect Nuclear Polyhedrosis Viruses

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Nuclear polyhedrosis viruses (NPVs) which infect Lepidoptera are DNA viruses of potential use as biological control agents. There have been several reports that RNA is in the polyhedral protein which surrounds the NPV particles but definite proof of its presence and/or source is lacking. An attempt was therefore made to apply autoradiography to ascertain whether RNA is present in PIBs. The *Trichoplusia ni* (cabbage looper) cell line of Hink was infected with *Autographa californica* (alfalfa looper) NPV and labeled with H^3-uridine (RNA specific). Tritium labeled thymidine was used as a positive control and H^3-glutamic acid and H^3-glucosamine were used in other treatments. Procedures were developed for extraction of PIBs from the cells, and slides were prepared for autoradiography. Because of the small size of PIBs and their adherence to the cells, difficulties prevented the gathering of conclusive results. Autoradiograms contained labeled cellular debris which prevented a clear demonstration of whether or not the PIBs are labeled. Indications are that there is little or no labeling on PIBs produced in the uridine labeled cells, thus suggesting that PIBs do not contain RNA. However, owing to cellular debris on the slides it was quite difficult to detect labeled PIBs in the positive control (thymidine treatment). In conclusion, it is necessary to improve methods of PIB purification without losing portions of the PIB which might be labeled. Autoradiography should then be a useful method to apply to the question of whether or not RNA is present in PIBs.

A Toxic Factor from the Established Cell Line, CP-169 (Hink): *Carpocapsa pomonella* (Lepidoptera: Olethreutidae)

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Spent media recovered from 5 out of 8 different insect cell lines contain factors toxic to the established cell line, TN-368 (Hink) (*Trichoplusia ni*) (Lepidoptera). The highest concentration was detected in media from CP-169 cultures. Both the TN-368 and the CP-169 lines have been adapted to TC199-MK (McIntosh *et al.*, 1973). Vertebrate cell lines proved not to elaborate material toxic to TN-368 cells. The toxic factor, designated CpT, is elaborated by CP-169 cells into the growth media. Supernatant media from freshly washed cultures were non-toxic for TN-368 cells. However, if such treated cultures were incubated for 24 hours, the toxic factor could be detected in the media. In addition, extracts from ruptured washed cells proved to be toxic. TC199-MK incubated at 30°C. for 3 months was non-toxic. CpT is filterable (.22μm Millipore filter), and is inactivated at 80°C. for 30 minutes. It has a low molecular weight, as shown by centrifugation, and the Cytotoxic Dose Fifty of a pooled sample is $10^{3.25}$ units/ml. CpT is believed to be a non-infectious agent since it cannot be passaged in TN-368 cells. Furthermore, electron microscopy of inoculated cultures revealed no virus or other infectious microbes, and cultures tested negative for mycoplasmas. The early appearance of a toxic effect 6 hours post inoculation, suggests a toxin.

Changes in Tolerance of *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae) to Insecticides in Relation to Larval Growth and Mixed-Function Oxidase Activity

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In vitro investigations have demonstrated mixed-function oxidase (MFO) activity in several tissues of gypsy moth larvae (Insect Biochem. 3:263, 1973; Int. J. Biochem. 5:11, 1974). The gut MFO activity, which is 67.8% of the total activity, rises markedly during larval development. The increase in the specific activity of this enzyme system in the fifth instar is ca. fivefold over the third instar (J. Insect Physiol. 21:85, 1975). The present communication reports the investigations on the effects of increase in the MFO activity on the susceptibility of advancing instars of gypsy moth larvae to carbaryl and diazinon. Topical tests showed that there is a continued increase in tolerance to carbaryl and diazinon with larval growth, with the result that 5th-instar larvae can tolerate 25× as much carbaryl and 50× as much diazinon as 2nd instars at the LD_{50} level; on a weight basis the tolerances are 1.9 and 4.5×, respectively. There is also a substantial increase in tolerance with growth within instars, but this is largely correlated with size. Piperonyl butoxide and 2,6-dichlorobenzyl-2-propynyl ether, inhibitors of MFO activity, are ineffective against 2nd instars, but with subsequent instars the activity increases greatly so that by the 5th instar only one-fifth the usual dose of carbaryl is needed to kill a larva when applied in combination with the propynyl synergist. The increase in tolerance to carbaryl and diazinon with larval growth, as well as increase in synergist efficacy, therefore, correlates with increases in MFO activity in advanced instars.

Oxygen Consumption of *Coleomegilla maculata lengi* Timberlake (Coleoptera: Coccinellidae) Measured in a Differential Respirometer

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A Gilson differential respirometer was used to measure O_2 consumption of adult female *C. maculata*. The respirometer had the capability of simultaneously measuring O_2 uptake in 14 separate vials. Field-collected beetles were tested singly and in groups of 10. Their respiration was monitored for 6 hr at 15 min intervals at each of 4 different temperatures; 6°, 12°, 18° and 24°C. At 24°C the respiration of beetles tested singly could accurately be determined. At reduced temperatures the differential respirometer fluctuated significantly thus introducing variation in excess of 0.01 μl O_2/mg/15 min. If 10 beetles were placed in each vial at 6°C variation was minimized and O_2 consumption could be measured. An O_2 consumption curve was established. Q_{10} values were similar to those reported for other insects. Oxygen consumption for *C. maculata* was 0.042 ± 0.013 μl O_2/mg/15 min at 6°C, 0.10 ± 0.005 at 12°C, 0.158 ± 0.011 at 18°C, and 0.316 ± 0.046 at 24°C. A Gilson respirometer can be used to measure O_2 consumption (at 24°C) of adult female *C. maculata* tested individually, but accuracy was decreased and variation increased as temperatures were reduced. If 10 beetles per vial were used the variation in O_2 consumption measurements was minimized. Adult female field-collected *C. maculata* respired at levels from 0.042 ± 0.013 μl O_2/mg/15 min at 6°C to 0.316 ± 0.046 μl O_2/mg/15 min at 24°C.

A Phylogeny for *Paracymus* Thomson (Coleoptera: Hydrophilidae) Based on Adult Characters

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An analysis of adult characters reveals that the 69 known world species of *Paracymus* fall into 6 distinct groups which, on the basis of distribution data, appear likely to be monophyletic. The characters examined included the form of the male genitalia, modifications of the male protarsi, the number of antennal segments, the form of the mesosternal modifications, the extent of mesofemoral pubescence, dorsal punctation and pigmentation, and the extent of development of a carina on the first visible abdominal sternite. Two species groups, restricted to the New World, have the penis very flattened in cross-section, the antennae 7 segmented and the mesosternal lamina well developed and reaching the mesosternal crest. In the *elegans* group, containing 15 species, the mesofemoral pubescence reach nearly to the knees, while the *nanus* group, with 7 species has the mesofemoral pubescence restricted to a basal triangle. In all other groups, the penis is thickened in cross-section, the antennae have from 7 to 9 segments, and the mesosternal lamina is less well developed. The *evanescens* group consists of 23 Old World species with rounded parameres and reduced mesofemoral pubescence. Two groups with extended mesofemoral pubescence are found in both hemispheres, although both are primarily New World. The *aeneus* group with 8 species has the parameres flattened in cross-section. The *subcupreus* group consists of 15 species with rounded parameres. The *secretus* group contains a single New World species with no mesofemoral pubescence.

Intra-instar Respirometric and Phase Distribution Differences in *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae) Larvae

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When investigations dealing with lepidopterous larvae are reported, the age, instar, or weight are used for identification. With *Trichoplusia ni,* larvae of a

given age have weights which are normally distributed, but the individuals may be distributed into more than one instar. Since the physiological state of a larva is not necessarily represented by age or instar, it is important to delineate any metabolic differences among larvae, and to determine the daily distributions of larvae by instar and phase within the stadium. A Gilson Differential Respirometer was used to measure respirometric rates of 4th and 5th instar *T. ni* 8 through 14 days post-eclosion. Larvae were morphologically segregated into 5 phases for each instar. Larval phase distribution within 4th and 5th instar could not be reliably predicted by age, and random selections did not yield reproducible phase proportions. Respirometry demonstrated significant differences between instars, and phases within the instars when rates were determined by μl O_2/mg wet weight/hr. When respiratory activity was assessed by accumulating the respiratory rates and fitting a regression line, $y = bx + c$, $c = o$, the slopes ranged from 0.41 to 0.93, depending upon the phase and instar. All regression lines had low residual mean squares, r-squared > 0.95, and were significant at $p < 0.01$. *T. ni* larvae did not follow a general trend of reduced respiration as age or weight increased. Respiratory rate appeared to be phase dependent. Since the phases within an instar were neither predictable by age nor were they metabolically homogeneous, experimental precision may be increased by designing tests with similar phase distributions of larvae in each treatment. This may be necessary to obtain meaningful comparisons or reproducible results if the physiological states of the insects can alter treatment effects.

The Oenocytes of *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae)

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The large, conspicuous, naturally yellow-colored, ectodermally derived oenocytes of *Tenebrio molitor* were studied in freshly dissected larvae, pupae and adults in unstained saline whole mounts, and were examined with ordinary light and with phase optics at magnifications of 50 to 1,000 times. The cells did not pick up any of a series of dyes (neutral red, ammonia carmine, pure carmine, trypan blue, alcian blue, methylene blue, toluidine blue or India ink) after these had been injected in varying concentrations into the hemolymph. On the other hand, the pericardial cells quickly absorbed these dyes. The fat bodies did not incorporate any of the dyes. The oenocytes showed no conspicuous cytological changes in either number, color or configuration relative to larval ecdysis, pupation, or maturation of eggs. Females with undeveloped, developing, and fully developed oocytes had oenocytes which were of the same general appearance as those in females which had recently laid their eggs. It is concluded from this study that the oenocytes of the mealworm do not form a part of an athrocytic system. Although the oenocytes are reported to produce a cuticular material near the time of ecdysis, and are said to be important in the development of the eggs, and are supposed to secrete a hemolymph protein, and are claimed to secrete ecdysone in some species, these cells in the mealworm exhibit no striking changes in their general anatomy which would lend support to their participation in any of these activities.

Symposium: "Solving Insectary Production Problems"

M. A. Hoy, Moderator

The Genetic Implication of Insect Mass Rearing Programs,
G. Bush, University of Texas, Department of Zoology,
Austin, Texas

Monitoring the Quality of Laboratory-Reared Insects,
M. B. Huettel, USDA, ARS, Gainesville, Florida

Improving the Quality of Laboratory-Reared Insects,
M. A. Hoy, USDA, Forest Service, NEFES,
Hamden, Connecticut

Genetic Changes Occurring in Flight Muscle Enzymes of the Screwworm Fly During Mass Rearing

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A preliminary population genetic study of genetic variation in laboratory and natural populations of the screwworm fly by gel electrophoresis of enzymatic and non-enzymatic proteins representing 36 presumptive loci revealed extensive differences in both allele frequency and the degree of heterozygosity. Further analysis indicated that the most rapid changes occurred during factory colonization in enzymes important to flight muscle metabolism and flight activity such as α-GDH and PGM. The fact that all factory-adapted strains eventually end up with similar genetic structure and greatly reduced genetic variability indicates that factory rearing conditions are exerting strong selection pressures for a "factory type."

Because screwworm adults are capable of dispersing long distances and mating may occur in the air or require some flight activity, monitoring for changes in enzyme systems essential to normal flight activity could prove to be a sensitive system for maintaining vigorous factory strains. Lab strains could also be tailored to fit changing environmental conditions between summer and winter using specific alleles.

Monitoring the Quality of Laboratory-Reared Insects

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The process of monitoring implies the use of a warning system with an element of periodicity. To be useful a monitoring system must be applicable on a routine basis, subject to the constraints of reproducibility, simplicity and economy. The quality of any particular trait may be defined as the difference between the trait in a wild insect and a laboratory insect. The overall quality of the laboratory insect, however, can only be measured in terms of how well it functions in its intended role when released into the field. It is the quality of traits which we usually attempt to measure with a monitoring system.

Laboratory insects should possess certain rather specific traits to perform well in the field. They should have life histories similar to the wild population. They must be able to disperse from the release site, find and utilize locally available nutrients, and locate mating sites (host plants and pheromones) or hosts or prey. They must be able to court and mate successfully in most cases. During their life span in the field they must also be able to survive local climatic conditions and avoid predators.

Each of these traits should be amenable to monitoring in the laboratory or field. Emphasis will be placed on identifying the monitoring system most applicable to each trait and its state of development as a useful method. Finally the possibilities for, and difficulties of, extrapolation from trait quality to field performance will be discussed.

Improving the Quality of Laboratory-Reared Insects

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Genetic improvement of insects has generated only a moderate amount of discussion in recent years because the problems of *maintaining* genetic quality have not been solved. However, certain insects have been improved genetically.

"Domesticated" insects such as honeybees and silkworms have long associations with man and have been improved in many ways. Some parasitoids have also undergone selection to improve insectary production and/or field effectiveness.

Parasitoids, or any insects destined to survive and reproduce in a natural environment, present particularly difficult problems for an improvement program. Desirable attributes to be selected must be clearly definable. Adequate genetic variability must be provided to allow selection to operate. Adequate selection procedures are a must. Finally, maintenance of the integrity of the improved strains under field conditions may need to be provided for.

Heterosis has been largely ignored in genetic improvement programs, except for the spectacular improvements exhibited in silkworm and honeybee improvement programs. Some data suggest that heterosis may be useful to improve the effectiveness of inoculative or inundative releases of parasitoids or predators. There is yet inadequate experimental evidence to judge the *general* value of selection and hybridization for improving insects. Future field testing will demonstrate the value of such improvement methods.

Symposium: Biosystematics

GORDON GORDH, MODERATOR

SYSTEMATICS AND ECOLOGY OF CHRYSOPIDAE (NEUROPTERA): THEORETICAL AND APPLIED IMPLICATIONS. CATHERINE A. TAUBER AND MAURICE J. TAUBER, DEPARTMENT OF ENTOMOLOGY, CORNELL UNIVERSITY, ITHACA, N.Y. 14853

SOME EVOLUTIONARY TRENDS IN THE CHALCIDOIDEA (HYMENOPTERA) WITH PARTICULAR REFERENCE TO HOST PREFERENCE. GORDON GORDH, SYSTEMATIC ENTOMOLOGY LABORATORY, AGR. RES. SERV., USDA.

TERRITORIALITY IN MALE BEES (HYMENOPTERA: APOIDEA). EDWARD M. BARROWS, DEPARTMENT OF BIOLOGY, GEORGETOWN UNIVERSITY, WASHINGTON, D.C. 20057

Systematics and Ecology of Chrysopidae (Neuroptera): Theoretical and Applied Implications

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The family Chrysopidae—green lacewings—is a member of one of the most primitive holometabolous orders (Neuroptera), and clarification of the evolutionary changes within the Neuroptera is not only of intrinsic value and interest, but it can contribute to an understanding of the evolution of the more highly evolved insect orders. In addition to their taxonomic value, many chrysopid species are useful as subjects in ecological-physiological studies, and as important predators in integrated control programs in various agricultural ecosystems.

Our recent investigations with the Chrysopidae encompass 4 categories: systematics, phenology, behavior, and biological control. The systematics work is based on a classical, comparative morphological approach and on data derived from experimental studies in phenology and behavior. By combining the results of morphological and experimental studies, we not only broaden the basis for the classification and thus advance the systematics of the group, but we also provide information essential to the use of Chrysopidae (e.g. chrysopid strains) as biological control agents (1).

Specifically, in the area of systematics, our studies with the Chrysopidae represent the 3 levels or stages of biological classification:

1. *alpha* taxonomy—The larvae of most North American species have not been described. To promote species identification, we have reared and studied larvae of most North American species and the process of description is well underway (2,3,4).

2. *beta* taxonomy—Comparative analyses of the larval morphology (3,4) and the biological characteristics of adults and larvae (5,6) provide a basis for a sound classification and for keys to the taxa.

3. *gamma* taxonomy—The phenological adaptations of geographically diverse populations are valuable indicators of species-complexes and evolutionary trends within the genus *Chrysopa*. Phenological studies, in combination with hybridization tests, contribute to an understanding of the genetic diversity and the evolutionary history of geographic populations (7).

Success or failure of biological control projects depends in large part on the degree to which selected strains of beneficial species are adapted to biotic and abiotic factors of particular environments. Our recent investigations have led to the recognition of strains or races within geographically diverse chrysopid species that are currently used as biological control agents. These strains are characterized on the basis of morphological, phenological and behavioral criteria (7,8), and our studies show that some of these strains are better adapted than others to particular localities and particular agricultural ecosystems (9).

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Some Evolutionary Trends in the Chalcidoidea (Hymenoptera) with Particular Reference to Host Preference

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Taxonomically, the parasitic hymenopteran superfamily Chalcidoidea is among the most poorly known within the Insecta because the number of systematists working on the group is small, the group is large, and progress has been slow. Presently, we recognize about 1,220 genera and 9,950 species of chalcidoids. Hosts for 27% of the genera are unknown.

I believe this superfamily ultimately will be recognized as numerically the largest and biologically most diverse insect group. Several sources of information and lines of reasoning lead me to this conclusion: (1) the chalcidoid host spectrum extends from ticks and spiders to aculeate Hymenoptera. (2) Rapid genetic recombination of superior genotypes and subsequent speciation has been accelerated among chalcidoids because generation time is short (sometimes less than 8 days), they possess several modes of parthenogenesis (arrhenotoky, thelytoky, deuterotoky), and intensive inbreeding via sibmating is widespread. (3) Chalcidoids demonstrate several host-exploitation strategies: they develop as obligate egg parasites, larval parasites, pupal parasites, egg-larval parasites, larval-pupal parasites, and many species are obligate or facultative hyperparasites. Thus, each insect species represents several potential niches for parasitic chalcidoids. Also, phytophagy has evolved several times in the Chalcidoidea. (4) Chalcidoids display a finite number of morphological types, but there are no *a priori* reasons why morphological criteria must accompany the species status; sibling species are abundant in the Chalcidoidea. (5) The Neotropical, Ethiopian, Oriental and Australian faunas are almost totally unknown.

Analysis of generic and suprageneric levels in the taxonomic hierarchy shows that different taxa of chalcidoids have adopted different progenative strategies, which are categorized as specialists, generalists and opportunists. Specialists attack a specific host-taxon, such as a genus or family (*Desantisca* spp. on *Latrodectus* spp.; *Chalcis* spp. on Stratiomyiidae); generalists prefer a habitat rather than a taxonomically cohesive group of hosts (*Zagrammosoma* spp. on leaf mining Lepidoptera and Diptera); opportunists also have host spectra that transcend ordinal and class limits, but they are not restricted to a particular habitat (*Dibrachys* spp., *Tetrastichus* spp.).

Analysis of chalcidoid biotic potential at the family level, based on parasite-taxa size, indicates that some exploitation strategies are more successful than others. Two families (Trichogrammatidae, 64 genera, 369 species; Mymaridae 59 genera, 794 species) are exclusively egg parasites and attack many host orders. The Encyrtidae (491 genera, about 1,700 species) have focused on the Homoptera, especially scale insects, and are among the most successful groups of parasites. The Pteromalidae (233 genera, about 1,400 species), while attacking innumerable taxa of hosts, most commonly parasitize Coleoptera and Lepidoptera. Extreme specialization does not necessarily reflect much generic diversity. Thus, the Leucospidae (4 genera, 127 species), parasites of solitary bees and wasps, and Eucharitidae (11 genera, 193 species), parasites of ants, have not evolved in great numbers.

Some phylogenetic considerations are made based on host preference, geographical distribution, taxon size and morphology.

Territoriality in Male Bees (Hymenoptera: Apoidea)

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Territoriality in male bees is their continued occupancy and defense of a topographic area or landmark against conspecific males. Their territories vary in size and in durations of ownership. Types of landmarks included are nests of conspecific females, all or certain parts of plants, pebbles, rocks, and patches of bare earth. Any of these landmarks may be rendezvous places, locations where a bee is likely to find a mate. Males, conspecific females, or both have been observed feeding, mating, and nesting in territories. The smallest territory is held for 3 to 10 days by the sweat bee, *Lasioglossum rohweri* (Ellis). It is a microterritory which is only about as large as the bee which defends it. Male *Centris pallida* Fox have digging microterritories above virgin females in soil. *Calliopsis andreniformis* Smith guards a territory 2 to 5 meters long and chases away its parasite, *Holcopasites*. Males of both *Calliopsis* and *L. rohweri* may function in nest defense. *Protoxaea gloriosa* (Fox), like other species, defends plants where it is likely to encounter females. The longest territory (38 m long) is held by *Anthidium banningense* Cockerell for at least 3 days and males of *A. manicatum* L. are among the most aggressive of all male bees. They chase and sometimes harm almost any insect except conspecific females encountered in territories. In the Galapagos Islands, the carpenter bee, *Xylocopa darwini* Cockerell, chases *Geospiza* finches as well as other insects. A European mason bee, *Hoplitis anthocopoides* (Schenck), varies the size of its territories with regard to its food plant and the numbers of conspecific males in a given area. These males hold territories for a median of about 16 days.

Factors believed to affect the cost/benefit ratio of territoriality include distribution and detectability of female emergence sites, detectability of nest entrances, distribution and quality of foraging areas, and the number of conspecific male competitors in an area.

Territoriality in male bees probably has manifold functions. It may function to increase the efficiency of natural resource utilization and of escaping from predators because males learn the topography of their territories quite well. Territoriality may space individuals over the available habitat, reducing competition for food and females. Furthermore, this behavior may reduce the incidence of disease and parasites and the time spent in agonistic encounters. Finally, if territories of a particular species cannot be compressed, territoriality may function in population regulation. Territoriality represents a group of adaptations that differ from one species of bee to the next.

Bee species with territorial males usually have relatively large males.

Territoriality in male bees is probably a result of convergent evolution. Because this behavior is found in isolated genera, in 7 of the 9 families of bees, it appears to be a derived, rather than an ancestral, type of behavior.

Symposium: Ecology of Forest Defoliators

Douglas C. Allen, Moderator

The Importance, Biology and Control of the Birch Casebearer, an Imported Pest, in Insular Newfoundland. Dr. David G. Bryant,
Newfoundland Forest Research Center, Canadian Forestry
Service, P. O. Box 6028, St. John's, Newfoundland,
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The Role of Defoliators in the Anthropod Community of Red Maple Crowns. Mr. Jan Volney, Maritimes Forest Research
Center, Canadian Forestry Service, P. O. Box 4000,
Fredericton, New Brunswick, CANADA E3B 5G4

The Douglas-fir Tussock Moth—Influence of Host Foliage.
Mr. Roy Beckwith, USDA, Forest Service, Pacific NW Forest
and Range Experiment Station, 3200 Jefferson Way,
Corvallis, Oregon 97331

CURRENT RESEARCH WITH *TELENOMUS ALSOPHILAE* VIERECK, AN EGG PARASITE OF THE FALL CANKERWORM. MR. ARNOLD T. DROOZ, USDA, FOREST SERVICE, FOREST SCIENCES LABORATORY, P. O. BOX 12254, RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

THE BIMODALITY OF GYPSY MOTH POPULATIONS. DR. ROBERT W. CAMPBELL, USDA, FOREST SERVICE, PACIFIC NW FOREST AND RANGE EXPERIMENT STATION, 3200 JEFFERSON WAY, CORVALLIS, OREGON 97331

Douglas-fir Tussock Moth, *Orgyia pseudotsugata* (McD.) (Lepidoptera: Lasciocampidae): Influence of Host Foliage

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The Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.) is one of the more important defoliators of Douglas-fir, *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco and true firs, *Abies* spp., in Western North America. Past outbreaks have occurred in fir forests from British Columbia south to Arizona. A resume of tussock moth biology is presented with special emphasis on host effects.

Tussock moth outbreaks are characterized by a rapid increase, followed by a sudden and complete collapse; the outbreak cycle usually spans a 3-year period in any one location. Endemic populations are extremely difficult to find by present standard sampling techniques.

The 1972–74 Blue Mountain outbreak in Oregon and Washington prompted a laboratory study on the effects of host foliage on the tussock moth. Three common hosts were used in the test; high density field populations were simulated by forcing one-half the population to feed upon old growth foliage following the second instar. This "stress factor" had the most significant effect upon the population, resulting in increased development time, frass production and mean number of instars, and a decrease in larval size, pupal weight, and egg production.

It appears that populations can increase equally well on grand fir and Douglas-fir; the degree of acceptance of old growth foliage may govern survival rate and ultimate tree damage. Although fed upon, subalpine fir will not support dense populations.

Only current foliage will be consumed during the release phase of a proposed hypothetical outbreak model (1), but larvae are forced to feed on old-growth foliage under high density populations in the outbreak phase which is detrimental to population survival. New foliage depletion in early instars leads to mass starvation, delayed development, increased exposure to biotic controls and general population collapse.

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The Role of Defoliators in the Arthropod Community of Red Maple Crowns

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The arthropod community on red maple foliage is organized into 5 guilds each of which remains comparatively simple throughout the growing season. The simplicity of the community may be a reflection of the comparatively simple structure of red maple crowns. Lepidopterous defoliators in 2 guilds dominate this community both in terms of biomass and their impact on the community. Leaf rollers, principally *Cenopis acerivorana* (MacK.), provide shelter for a variety of organisms in the leaf roll and thereby tend to increase the number of species in the community. *Itame pustularia* (Gn.), a solitary defoliator, which occurred in high numbers in one plot, initially reduced the species diversity of the community. However, the reaction of the host trees to heavy defoliation resulted in an arthropod community with a higher index of diversity towards the end of the season. Population levels of those defoliators which dominate the community also have a considerable influence on the composition of this community. Trophic bonds between the defoliator guilds are practically nonexistent in the populations studied. Similarly, trophic bonds with the arthropod communities on other host species in the same stands seem tenuous. The implications of these results on the process of stand succession in central New Brunswick is speculated upon.

Current Research with *Telenomus alsophilae* Viereck, an Egg Parasite of the Fall Cankerworm, *Alsophila pometaria* (Harris) (Lepidoptera: Geometridae)

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By way of background information, the rationale for our work on *Telenomus alsophilae* Viereck takes us back over 20 years, when an outbreak of the elm spanworm, *Ennomos subsignarius* (Hübner) arose in northern Georgia. This outbreak lasted 10 years, covering 1.6 million gross acres in the southern Appalachian Mountains at its peak in 1960. Spanworm populations declined in 1963, and egg masses could not be located after the hatch of 1964. At that time an egg parasite determined to be *T. alsophilae* was found in an average of 85% of the spanworm eggs; few of these loopers became final instars, and pupae could not be found. Hardly any information was available about *T. alsophilae* at that time. It obviously was time to examine the details of the biology of so important a parasite. However, the spanworm outbreak was over and little could be done to initiate work on *T. alsophilae*. What could be done would have to be carried out with a more common host, the fall cankerworm and laboratory-reared spanworm eggs. The inevitable problem arose when at that time it was impossible to rear the fall cankerworm and the cankerworm parasites would not attack the spanworm eggs. These problems, and the observation that cankerworm eggs are attacked in the late fall through winter in the mountains of North Carolina, while the spanworm eggs are only attacked in April/May, prior to hatch, needed to be resolved. Therefore, a research program was developed whose objectives were:

1. Rear the fall cankerworm for use as host material.
2. Study the relationships between *T. alsophilae* attacks on the cankerworm and spanworm in the field.
3. Rear *T. alsophilae* upon demand.

Work was begun in the winter of 1970/71 to rear the cankerworm and learn about parasite emergence, sex ratios and longevity. We succeeded in our efforts to rear the cankerworm, but so far the results are not worth the effort. It can be reared either on an artificial diet or on host foliage, but prolonged emergence and the predominance of females, which also occur in natural populations, defeat the purpose. G. F. Fedde tested the eggs of numerous potential hosts, and found a number of geometrid and noctuid hosts were satisfactory, but he found that a relatively unimportant forest geometrid, *Abbotana clemataria* (J. E. Smith) is an excellent laboratory host for *T. alsophilae*. V. H. Fedde has reared this geometrid with little difficulty on a diet she developed for the spanworm. This breakthrough was much needed, and has permitted us to achieve our goal of producing *T. alsophilae* and some other species of egg parasites on demand, as well as investigate details of the biology of *T. alsophilae* in the laboratory.

Where are we in our work with the field relationships between *T. alsophilae*, the cankerworm and spanworm? Through our field observations on time of parasite attack on eggs of these hosts, arena studies in the laboratory, and reexamination of specimens from the 2 geometrids, USDA specialists indicate that the *Telenomus* attacking the elm spanworm is a new species. Therefore, we have another potentially useful insect to investigate if we can obtain a starter culture and can rear it in the laboratory.

Along practical lines, being able to rear *T. alsophilae* has permitted us to send quantities of parasitized eggs to A. E. Bustillo in Medellín, Colombia where he has made successful sleeve-cage tests with *T. alsophilae* against *Oxydia trychiata* (Guenée). This insect is one of several geometrid species killing the introduced cypress, *Cupressus lusitanica* Miller.

Within the next few years a number of scientific papers should be published by our group concerning details of the biology of *T. alsophilae*. We believe that they will provide much useful information to the field of biological control about a valuable species or two which were neglected in the past.

The Importance, Biology and Control of the Birch Casebearer, *Coleophora fuscedinella* Zeller (Lepidoptera: Coleophoridae), an Imported Pest in Insular Newfoundland

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The birch casebearer, *Coleophora fuscedinella* Zeller, was introduced into North America from Europe about 1920 (1) and has been found attacking several broad-leaved tree species such as birch, *Betula*, and alder, *Alnus*, causing severe browning of foliage, branch mortality and occasionally death of host trees. It was first found in Newfoundland in 1953 and occurs on its principal host white birch, *B. papyrifera* Marsh.

The Province is in the Boreal Forest region and white birch comprises about 12% of the standing tree volume. The tree is little used for either lumber or pulp and has its greatest importance as an aesthetically valued component of the landscape. Over 30% damage to leaves (defoliation) brings public enquiries (2). At over 90% defoliation, branch and twig mortality becomes apparent. There is a high variation in total defoliation among trees in a stand and we have not been able to identify the cause of the variation. Within trees, defoliation is concentrated in the peripheral 25 cm of crown and is least variable in the 2 middle crown quarters.

The casebearer has one generation a year. Eggs are laid on the leaves in July and larvae hatch 3 weeks later. These larvae mine leaves in August and molt to the second instar and construct a case from the leaf epidermis in September. The casebearers overwinter at a crevice on the bark and molt to the third instar in the spring before feeding. The fourth instar larvae construct a new case in June, feed for a short period, then pupate on the tree or ground vegetation (3).

Larvae are distributed throughout the tree but at any instar the majority are situated in the outer 25 cm of the middle half of the tree crown (4). The majority of leaves in a tree are in the 25 cm periphery and are the cause of the casebearer population concentrating in this portion. There is a high and sometimes significant ($P \leqslant 0.05$) variation in larval numbers between trees. The cause of the variation is unknown and is not related to tree variables of height, size, form, exposure, or dominance. Within trees, differences in larval numbers are most pronounced ($P \leqslant 0.05$) among 25 cm shells and occur occasionally among crown quarters.

Inter-tree variation was too high to obtain significant correlations of casebearer numbers and defoliation within stands. For data from all stands however, there was a significant correlation ($0.48 < r < 0.74$; $P \leqslant 0.05$) between defoliation and eggs, overwintering cases and late-instar larvae. The precision of defoliation prediction is low because of high inter-tree variation. Methods are being prepared to forecast defoliation classes from casebearer abundance.

Survival of casebearers during a generation appears to be constant at all population levels. About 40% of larvae survive winter (5) and about one-fifth of these pupate. This constant mortality suggests that the causes are intra-specific or relate to the insect-host interaction. High egg mortality of 90%, especially at high population levels, has been recorded (6) but the cause is unknown. Parasitism of larvae and pupae was extremely low at less than 5%, and parasites, native to European populations, are being introduced (7). Where defoliation is expected to affect aesthetic values, spraying at first green in the spring is recommended (8). On large ornamental trees systemic insecticides are suggested.

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The Bimodality of Gypsy Moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae) Populations

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Populations of the gypsy moth (*Porthetria dispar* (L.)) in North America have 2 numerical phases. A population may remain in the innocuous phase for many years, and the outbreak phase may continue within a general area for as much as a decade. Changes from the innocuous phase to the outbreak one and vice versa, however, usually take place within 2 or 3 years. Our records, which span a sizeable sample of natural gypsy moth populations in the northeastern United States between 1911 and 1975, show no tendency among these populations toward the regular oscillations characteristic of gypsy moth populations across much of Europe.

A procedure was developed to determine at what point during the generation the numerical differences appear between a sparse population in an outbreak area and one in an innocuous area. This study led to the following conclusions:

1. From 50 to 100 times as many eggs were produced by initially sparse populations in the outbreak area (Glenville, N. Y., 1958–1964) as by equally sparse populations in the innocuous area (Eastford, Conn., 1965–1968).
2. More than 90% of the difference between the 2 areas in mean number of eggs produced was caused by differential mortality during instars I to III, IV to VI, and the pupal stage, and by a lower proportion of females among the adults in Eastford.
3. The apparent survival during instars I to III was much lower in Eastford than in Glenville when egg density at the start of the generation was low. Survival was about equal in the 2 areas, however, when egg density increased.
4. Survival during instars IV to VI was about the same in the 2 areas when egg density was low, but it decreased rapidly in Eastford when egg density increased.
5. Survival of pupae was much lower in Eastford across the entire range of egg densities that was common to the 2 areas. Interestingly, the survival of pupae was relatively invariant *within* each area.
6. Differences between the 2 areas in the proportion of females among adults were minor when egg density was low, but increased as egg density increased. Since the sex ratio of gypsy moth eggs is known to be constant at 50:50 (2), and since the sex ratio of instar IV larvae is known to have been relatively invariant in the areas studied at about 65% females (1), it seems safe to assume that the significant differences between the 2 areas in the proportion of females among adults were determined during instars IV to VI, the

pupal stage, or both. Thus, not only do substantially more insects in the outbreak area survive instars IV to VI and the pupal stage, but more of the survivors are females.

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BOOK REVIEW

Man against Tsetse: Struggle for Africa. John J. McKelvey, Jr. Cornell University Press, Ithaca and London. 1973. 306 pp. $12.50.

Entomologists will be fascinated by the author's analysis of the development of knowledge on sleeping sickness and nagana disease of cattle, and how the large continent of Africa was influenced by contributions of medical entomologists. But this book is not merely an account of historical and scientific events and discoveries; it analyses in depth the complicated interrelations that the author, who has spent many years in Africa, has known from his own experience. The book is written by a scientist, who, as readers will find, is also an extremely accomplished writer and master of the language. The book thus provides many enjoyable hours. I am certain that my colleagues who read it will find perusal of this volume to be both informative and pleasurable. It gives much useful data to entomologists, epidemiologists, physicians and microbiologists. The author, a Director for Agriculture of the Rockefeller Foundation, is a knowledgeable medical entomologist (Ph.D., Cornell U.), a scholar, and an expert on Africa.

This book should be read by anyone who plans a trip to Africa—be it for scientific reasons, business, or for pleasure. No special training in entomology is required and the book will be enjoyed by entomologists as well as by laymen who want an authoritative, up-to-date view of the field. The author has succeeded admirably in bringing together for the first time the information on the tsetse fly, the trypanosomes, and the development of African nations. It will therefore serve both as a thorough review of the history and present status of the problem for college students, and as a guide to the literature for serious researchers. The Chapter Notes (pp. 239–292) are very valuable for the latter. An index of 13 pages completes the volume.

There was a definite need for a book on sleeping sickness and at last we have one, written by an extremely competent authority. It ought to be in every public and highschool library so as to become for young men and women interested in Africa's future and medical entomology what Paul DeKruif's "Microbe Hunters" became for future microbiologists—the stimulus to devote one's life to a deserving cause. I found "Man against Tsetse" as stimulating as DeKruif's book, and at the same time more accurate and up-to-date. Years of careful research have been spent by the author in searching and checking all the data and facts.

The tsetse fly had an enormous impact on Africa's development. Great strides have been made in controlling the insects and in chemotherapy of the disease. Nevertheless, there remains the dangerous potential for an epidemic, as demonstrated in recent, new outbreaks of sleeping sickness. This is pointed out succinctly by McKelvey. The book will remain invaluable for a long time to come to those engaged in biological, medical and agricultural research.

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